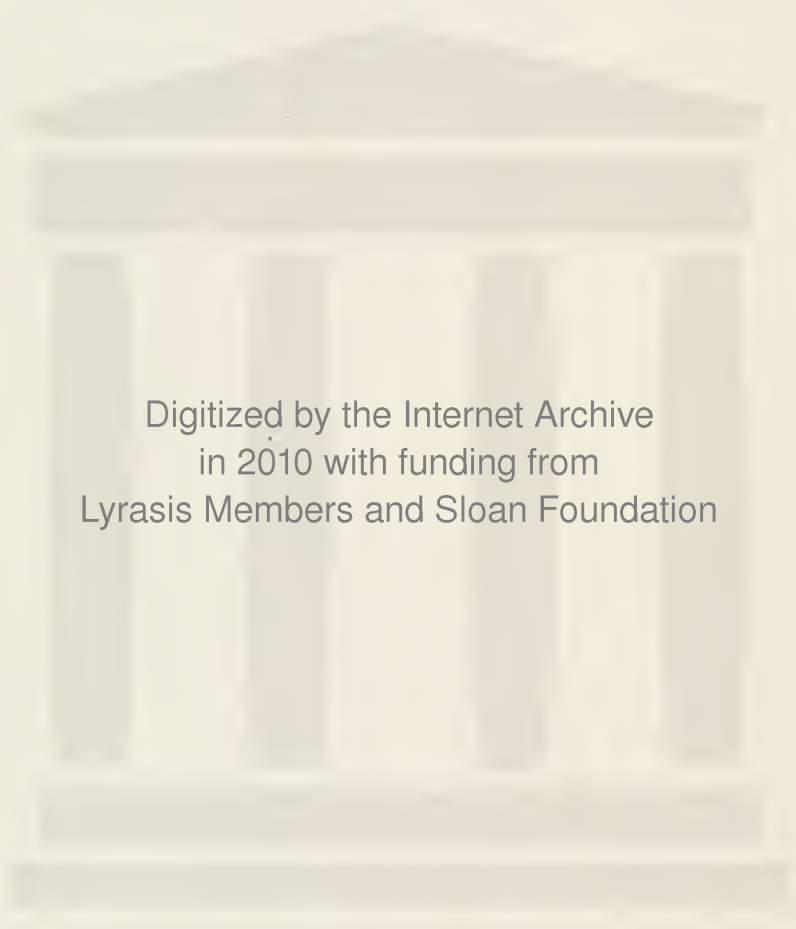


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Growth, Yield and Fruit Quality of 'Delicious' Apple Strains

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Authors

Tara A. Baugher is extension specialist, horticulture and associate professor of horticulture; Suman Singha is professor of horticulture; Edwin C. Townsend is professor of statistics and Morris Ingle is professor of horticulture, all in the College of Agriculture and Forestry, West Virginia University

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**West Virginia University
Agricultural and Forestry Experiment Station
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Summary

Thirty-four currently available strains of 'Delicious' apple were compared in a planting established in 1981 at the West Virginia University Experiment Farm in Kearneysville, WV. Trunk cross-sectional area was measured at the beginning of each season, and measurements of yield and fruit color, size, shape and quality were made during the first four cropping years (1985-1988). Strains that ranked high in attributes considered important for fresh market production under West Virginia growing conditions were 'Scarlett Spur', 'Cascade Spur', 'Ace', 'Oregon Spur II', 'UltraRed', 'Nured Royal', 'Silver Spur', 'UltraStripe' and 'Redchief' (Campbell). Selecting from among these top performing strains involves decisions regarding specific climatic conditions, management schemes and market requirements.

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Growth, Yield and Fruit Quality of 'Delicious' Apple Strains

Tara A. Baugher, Suman Singha,
Edwin C. Townsend and Morris Ingle

Introduction

'Delicious' is the major apple cultivar grown in West Virginia and the world. Twenty-eight percent of the apples grown in the state and 37% of the apples grown in the world are 'Delicious' (Brueggen et al., 1988).

The original 'Delicious' apple, discovered in 1879 (Fisher and Ketchie, 1989), has virtually been replaced by strains of markedly improved color. Over 100 red strains or mutations of 'Delicious' have been identified. In studies where strain color has been compared, either by consumer acceptance panel or colorimeter techniques, significant differences have been identified (Crassweller et al., 1984; Dennis, 1987; Fisher and Ketchie, 1989; Olsen and Ketchie, 1978). Since color development is strongly influenced by climatic conditions, it is important to establish separate trials in each apple growing region (Fisher and Ketchie, 1989; Ketchie et al., 1978; Olsen and Ketchie, 1978).

Strains of 'Delicious' are also selected for compact growth habit and increased productivity. Strains with the non-spur growth habit are being replaced by spur type strains. The most recent West Virginia Fruit Tree Survey (Brueggen et al., 1988) shows that 38% of the state's 'Delicious' are spur types. The productivity of 'Delicious' is low compared to other cultivars, and while some studies have shown no increase in yields with spur type strains (Lord et al., 1979), others have demonstrated increased yield efficiencies (Dennis, 1981; Ferree et al.,

1982; Ketchie, 1986). Differences in consistency of production have also been reported (Ferree et al., 1982). Characterizing strains as spur types or non-spurs can be misleading as, the degree of "spuriness" can vary. Other methods of defining growth habit include visual ratings (Crassweller and Hollander, 1988) and number of spurs per meter (Ketchie, 1984).

Additional considerations in selecting strains of 'Delicious' include fruit size, shape, date of maturity and quality. Some studies have shown that fruit on spur type strains tend to be typier than on non-spurs (Lord, 1982; Meheriuk et al., 1973), but most research has shown minimal differences (Ketchie, 1986). Distinctions in fruit quality and maturity have been difficult to ascertain due to varying climatic conditions, nutrition and cultural practices. Greener flesh and lower soluble solids have been reported for spur type strains compared to non-spurs, but it is unclear whether the data indicate differences in fruit maturity or reduced dessert quality (Ingle, 1972, 1989; Olsen and Ketchie, 1978).

Planting intentions indicated in fruit tree surveys suggest that 'Delicious' will continue to be a dominant fresh market apple cultivar. With decreased use of growth regulators and increased market competition, it is imperative that growers plant only strains with the right combination of characteristics for a given microclimate, management scheme and market. The major objectives of this study were to compare fruit color, tree growth, fruit size and length/diameter (L/D) ratio, and fruit quality of recently introduced 'Delicious' strains under West Virginia growing conditions, using locally recommended management practices. New strains of 'Delicious' have been continually introduced, and strain evaluation is an on-going process.

Materials and Methods

Thirty-four currently available strains of 'Delicious' apple were planted in 1981 and 1982 at the West Virginia University Experiment Farm, Kearneysville. Plots were arranged in a randomized block design, with two five tree replicates separated by 'Golden Delicious' pollinizers. Tree spacing was 4.9 m by 6.1 m for a density of 336 trees per hectare.

Major characteristics of the strains are presented in Table 1. 'Starkrimson', 'Topred', and 'Red Prince', strains commonly planted in West Virginia, were included as standards for comparison. The remaining strains had not been evaluated under West Virginia growing conditions. The majority of the strains were on M. 7a rootstock, and other rootstocks were substituted only when the requested rootstock was unavailable. Trunk caliper of the trees was 16 mm at planting.

The soil at the test site is a Hagerstown silt loam, a common orchard soil in the state. The site was prepared according to local Extension recommendations. Trees were planted with a commercial tree planter, with bud unions set at 2.5 to 5.0 cm above the soil line. Kentucky-31 fescue was planted in the row middles, and herbicides were applied annually to the tree rows. Fertilizers and pesticides were applied according to Extension Integrated Orchard Management recommendations. Trees were pruned and trained to the Heinicke central leader system (Heinicke, 1974). Carbaryl was applied as a chemical thinner at 10 mm average fruit size in 1985-1988.

Trunk cross-sectional area (TCSA) 20 cm above the soil line was determined each spring before active growth began. Yield per tree and per cm² TCSA were determined in each of the first four cropping years (1985-1988). Ten fruit per replicate were randomly sampled at 145-150 days after full bloom (DAFB) in each year for quality evaluations, including color ratings (by consumer panel instructed to visually rate overall color on a 1 to 10 scale), soluble solids (with a hand-held refractometer), firmness (with an Effegi penetrometer), starch index (Priest and Loughheed, 1981), diameter and L/D ratio. The date of harvesting samples in each year was determined to be within the optimum range for all strains. In agreement with previous research that has indicated insignificant differences in maturity due to strain variation, all strains matured at a similar rate. Data were subjected to analysis of variance, and means were separated by least significant difference (LSD).

Table 1.
Basic characteristics of 'Delicious' strains at the
WVU Experiment Farm, Kearneysville.

(Trees planted 1981 unless otherwise indicated.)

Strain	Rootstock ¹	Growth Habit ²	Growth Rating ³	Fruit Color Pattern ⁴
Ace Red Spur	M. 7a	S	2	S,B
Alred	MM111	NS	10	S
*Aomori	M. 7a	NS	10	S
Apex Spur	M. 7a	S	3	S,B
Bright 'n Early	M. 7a	S	5	S,B
*Cascade/Starkspur				
Compact	M. 7a	S	2	B
Classic	M. 7a	NS	9	S
Hardi-Brite Spur	MM106	S	3	B
Imperial	M. 7a	NS	6	B
Improved Ryanred	M. 7a	NS	6	S,B
Nured Royal	M. 7a	NS	8	B
Oregon Spur	MM106	S	4	S
Red King Oregon Spur (Oregon Spur II)	Seedling	S	4	S,B
**Redchief (Campbell)	M. 7a	S	2	S,B
Red Prince	M. 7a	NS	7	S
Redspur	M. 7a	S	3	B
Rose Red	MM111	S	4	B
Ruby Red	Seedling	S	3	B
Ruby Stripe	Seedling	S	3	S
Ryanred Spur	M. 7a	S	3	S
Scarlett Spur	Seedling	S	5	B
Sharp Red	M. 7a	NS	7	S
Silver Spur	MM111	S	4	S,B
Spur Red	MM111	S	2	B
*Starkrimson (Bisbee)	M. 7a	S	3	B
*Starkspur DixieRed	Seedling	S	3	B
*Starkspur Supreme	M. 7a	S	4	B
*Starkspur UltraRed	M. 7a	S	3	S,B
**Starkspur UltraStripe	M. 7a	S	3	S,B
Sturdeespur	M. 7a	S	3	S,B
*The Real McCoy	M. 26	S	5	S
Topred	M. 7a	NS	10	S
Topspur	M. 9/MM111	S	3	S,B
Triple Red	M. 7a	NS	10	S
Wayne Spur	MM111	S	3	S,B
Wellspur	M. 7a	S	5	B

¹Rootstock of choice was M. 7a; substitutions made only when requested rootstock was unavailable.

²S = spur type; NS = nonspur.

³B = blushed; S = striped; S,B = striped early turning to blush at harvest.

⁴Vigor rated visually on a scale of 1-10, with 1 being most heavily spurred and/or most compact. 1-5 = spur types; 6-10 = nonspurs.

*Planted in 1982.

**Planted in 1983 and included for color comparisons only.

Results and Discussion

In the discussion that follows, all strains were compared except where statistical analysis showed an influence of the rootstock on the scion. The rootstock effects which should be considered when interpreting the data are as follows:

TCSA - Trees on seedling were larger than those on M. 7a; trees of the one strain on M. 9/MM111 were smaller than all other combinations.

Cumulative Yield - Yields of strains on MM106 were greater than yields on all other rootstocks; yields of strains on MM111 were greater than those on seedling. Cumulative yield efficiencies of strains on MM111, MM106 and M.7a were higher than strains on seedling.

Soluble Solids - Trees on M. 26 and M. 9/MM111 had higher soluble solids than trees on MM106, MM111, or seedling; trees on M. 7a had higher soluble solids than those on seedling.

Influences of planting year existed only for TCSA and yield. For brevity, four-year means are represented in the figures included in the text, and one-year means are shown in the appendices.

Color

Strains with four-year color means greater than 6.5 received high color ratings in all years (Figure 1; Appendix A). Strains with four-year means less than 6.5 were variable or were consistently rated low. Based on statistical analysis of color ratings 'UltraStripe' had the most desirable color and 'Alred' the least. Coefficients of variation (an indication of how variable the ratings were among years, i.e. a low value indicates greater consistency) revealed that the ratings for some strains were more consistent than others. For example, 'Hardi-Brite Spur' and 'Real McCoy' were consistently rated as low coloring strains whereas 'UltraStripe' and 'Scarlett Spur' were consistently rated high coloring strains. Other studies conducted in this planting indicated that color ratings at 145 days after full bloom were positively correlated to earliness of color and to colorimeter measurements (Singha et al., 1989, 1990). Color ratings were influenced by color pattern, with striped and blushed combinations rated significantly higher than striped apples, and blushed apples rated intermediate ($p = 0.05$). Spur-type growth habit was not correlated with high color ratings, which is in agreement with other reports (Dayton, 1964).

Tree Size and Productivity

Apple tree size is highly correlated with TCSA (Westwood and Roberts, 1970). Based on TCSA in this study (Figure 2; Appendix B), the largest trees were 'Topred', 'Aomori' and 'Classic' and the smallest were 'Topspur'. All smaller trees were spur types, and all of the larger trees were non-spur. Spur density (number of spurs per meter) was determined for the strains on M. 7a and reported in 1990 (Warrington et al., 1990). Spur strains, for example 'Sturdeespur', generally had spur densities greater than 20 per meter. Spur densities for 'Sturdeespur', 'Redchief (Campbell)', 'UltraStripe', 'Redspur', and 'Ace', were 39, 38, 36, 33 and 33 per meter, respectively. Spur densities of 15, 16, 18, and 18 were found for 'Nured Royal', 'Sharp Red', 'Topred', and 'Aomori', respectively.

Strains with more than 50 kg cumulative yield per tree (Figure 3, Appendix 3) included 'Wayne Spur', 'Silver Spur', 'Imperial', and 'Cascade Spur' (strains on MM106 excluded due to a rootstock effect). Those with less than 20 kg included 'Bright 'n Early', 'Triple Red', 'Sharp Red', 'Aomori', 'Rose Red' and 'UltraRed' (strains on seedling excluded due to a rootstock effect). Coefficients of variation indicated that 'Wayne Spur' produced the most consistent yields. The most precocious strains also had the highest cumulative yields. Spring frost reduced the crop of all strains in 1987. Five days of cloudy weather two weeks after bloom reduced fruit set in 1988. The influence was greater on some strains than on others. Of the strains on M. 7a rootstock, cumulative yield efficiency (Figure 4) was 1 kg per cm² or higher for 'Ace', 'Cascade Spur', 'Sturdeespur', 'Imperial', and 'Apex'. As reported previously (Warrington et al., 1989), spur density was positively correlated with yield efficiency ($p = 0.05$).

Fruit Size, Shape and Quality

Mean fruit diameter, across all strains for the four-year period, was 7.9 cm, and mean L/D ratio was 0.86 (Appendix C). Strains with the largest mean diameters were 'Oregon Spur', 'Silver Spur', and 'Imperial', and those with the smallest diameters were 'Ruby Red' and 'Triple Red' (Figure 5). 'Supreme' was the typiest of the strains, and 'Ryanred' was the least typey (Figure 5). Although differences in L/D ratio were small, spur type growth habit was positively correlated with typiness ($p = 0.05$).

Mean fruit maturity indices, for all strains over four years, were as follows: firmness - 14.5 lb; soluble solids - 13.9%; and starch index - 4.6 (Appendix D). Strains with four-year starch means above the minimum suggested for shipping (a rating of 5) were 'Ultrared', 'Cas-

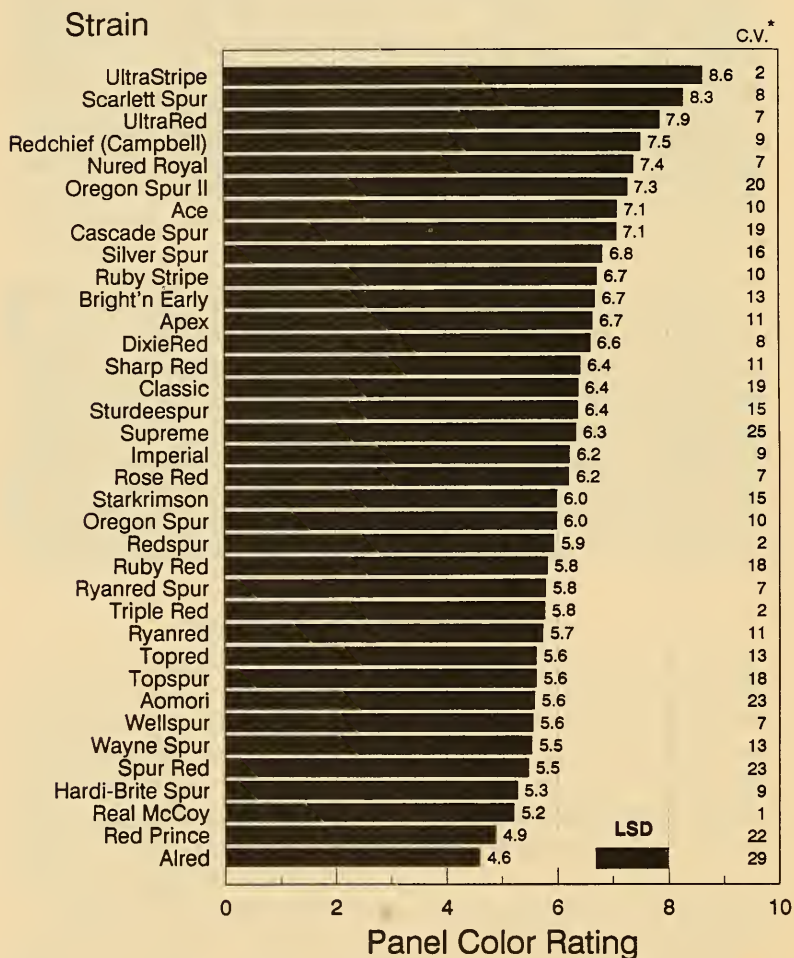
cade Spur', 'Sturdeespur', 'Imperial', 'Starkrimson', 'Redspur' and 'Real McCoy'. Based on starch, none of the strains were over-mature when harvested (Figure 6). Four-year firmness means were generally below the minimum suggested for shipping (15 lb), probably because the trees were young and most had a light crop load. Those which were at or above the minimum firmness for shipping included 'Nured Royal', 'Classic', 'Supreme', 'Topspur', 'Topred', and 'Aomori' (Figure 7). All soluble solids means were above the 11.5% level recommended for shipping (Figure 6). As suggested by investigators from other regions, we were unable to determine sequence of ripening from soluble solids, starch and firmness, either as separate indices or combined. Nonspur growth habit was correlated with high soluble solids and spur-type growth habit with low soluble solids ($p = 0.05$). Sensory evaluations of flavor and crispness were conducted on some of the strains in the test block in 1987, and the results varied depending upon whether the evaluation was conducted at harvest or 60 days after harvest (Crassweller and Hollander, 1988).

Overall Acceptability

Principal characteristics of the 34 strains in the Kearneysville planting are presented in Figure 7. The level of importance of each characteristic will vary among growers, depending on individual marketing and management schemes. For instance, if color alone is a high priority for a particular market, 'Scarlett Spur' is a leading choice. On the other hand, if equal importance is placed on color and productivity, 'Cascade Spur' and 'Ace' are better options. If major concerns are color and L/D ratio, 'Scarlett Spur' and 'Oregon Spur II' are the two leading selections. Differences in maturity are not distinctive.

Figure 1.
Mean consumer panel color ratings of fruit of
'Delicious' strains harvested 1985-1988.

Panelists were asked to visually rate overall color (including intensity, percentage of red surface area and uniformity among apples) on a scale of 1 to 10, with 1 representing poor color and 10 representing excellent color.



*C.V.=coefficient of annual variation

Figure 2.
Mean cumulative trunk cross-sectional areas of
'Delicious' strains, 1982-1988.

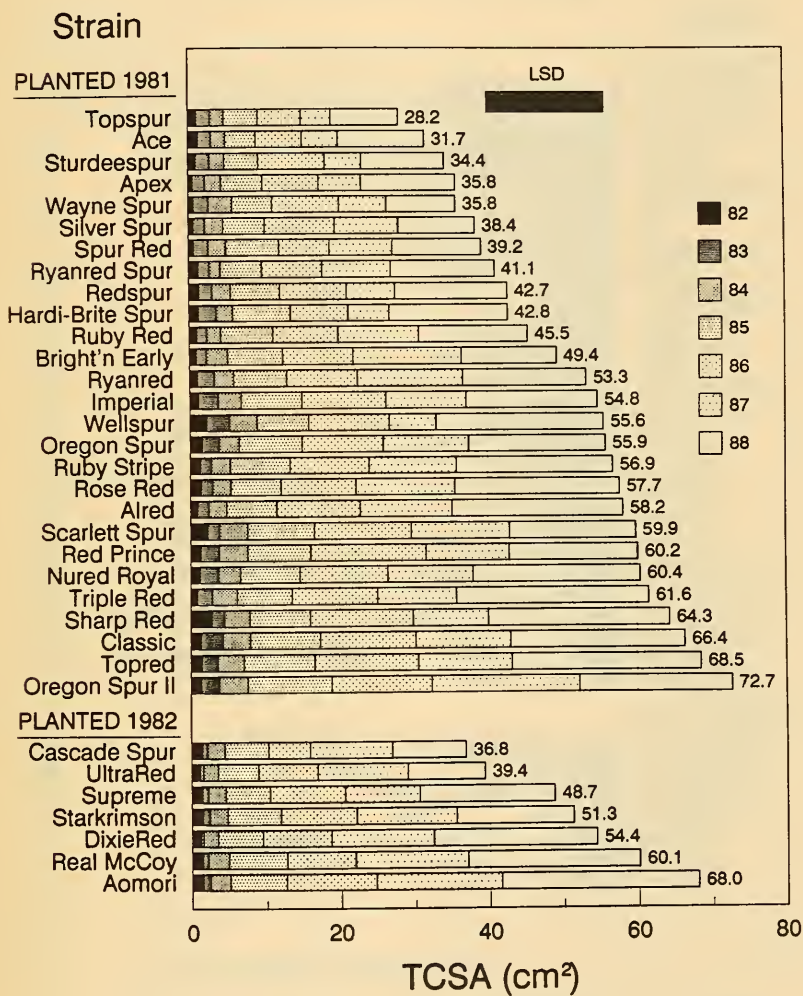
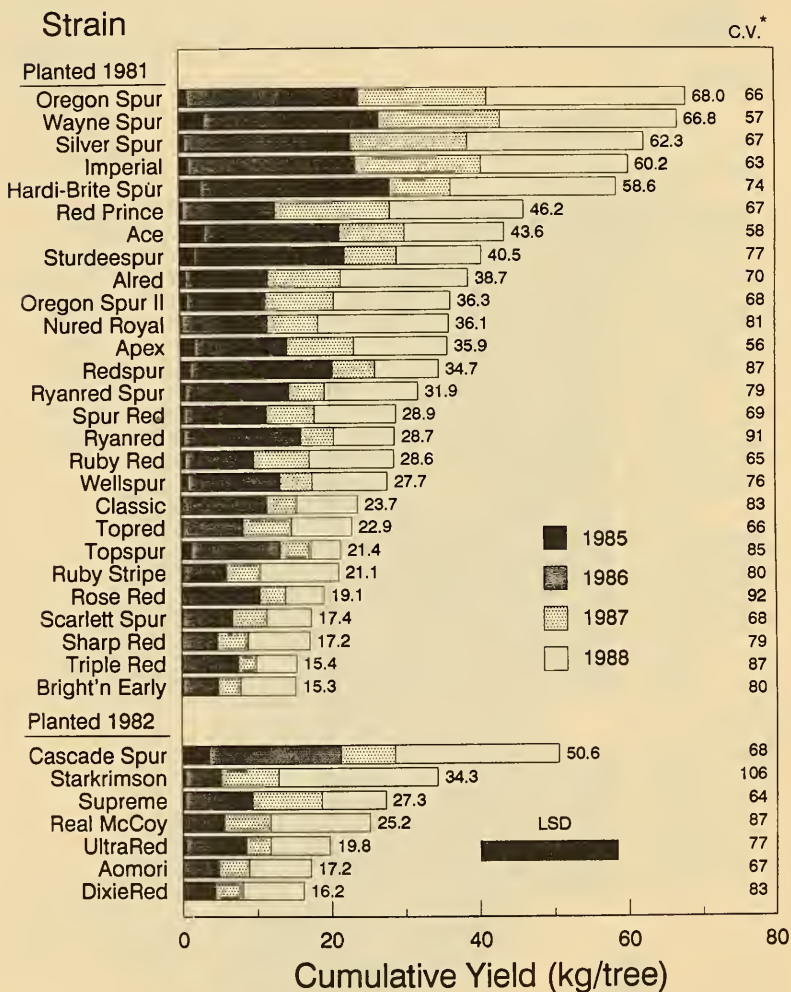


Figure 3.
Mean cumulative yields of 'Delicious' strains
1985-1988.



*C.V. = coefficient of annual variation

Figure 4.
Mean cumulative yield efficiencies and consumer
panel color ratings of 'Delicious' strains on
M.7a rootstock 1985- 1988.

Panel Color Rating (1-10 scale)



Figure 5.
Mean diameters and length/diameter ratios of
fruit of 'Delicious' strains 1985-1988.

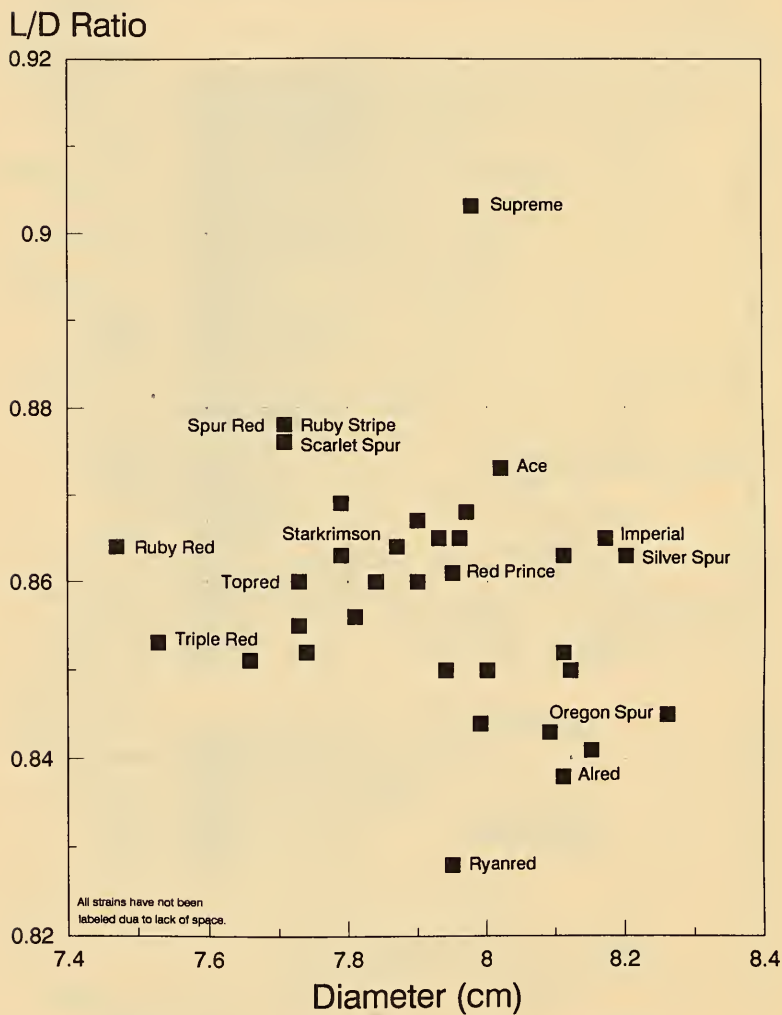


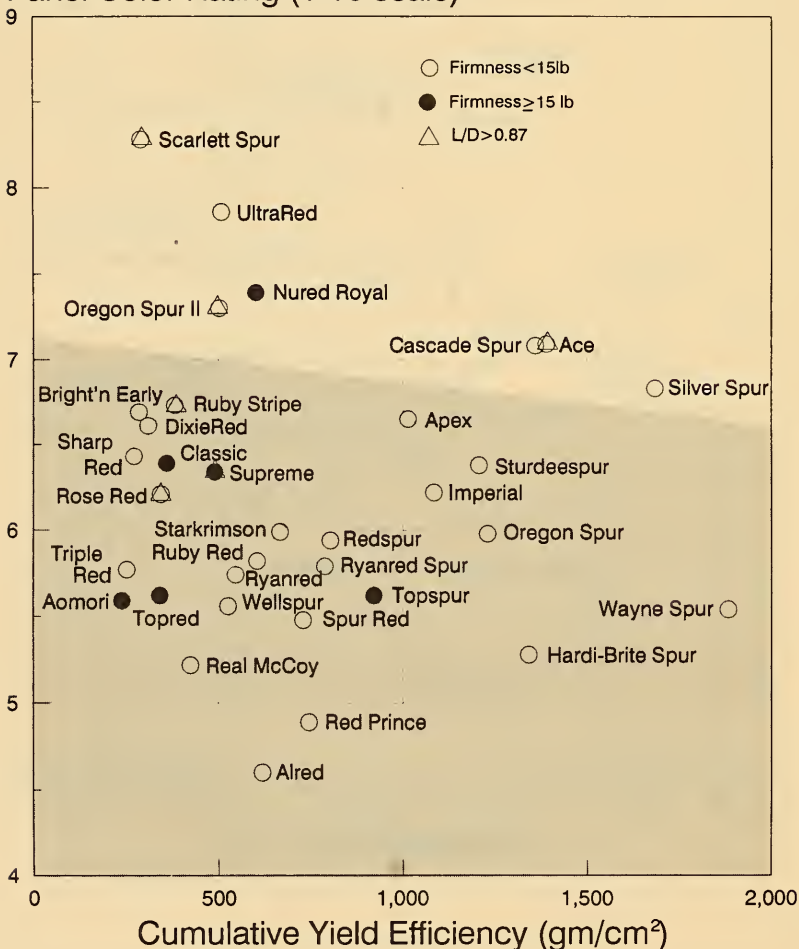
Figure 6.
Mean soluble solids and starch indices of fruit of
'Delicious' strains 1985-1988.



Figure 7.
Mean cumulative yield efficiencies and consumer
panel color ratings of 'Delicious' strains.

Symbols indicate which strains met minimum standards for firmness and/or were most typey (based on 1985-1988 means). Unshaded area of figure shows strains with the greatest potential – based on one or more characteristics – under West Virginia growing conditions.

Panel Color Rating (1-10 scale)



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Appendices

Appendix A.

Color ratings of 'Delicious' strains.

STRAIN	Color Rating (1-10 scale)				
	1985	1986	1987	1988	Mean
Ace	6.3	6.7	7.4	7.9	7.1
Alred	4.4	NA	6.0	3.4	4.6
Aomori	-	7.1	5.0	4.7	5.6
Apex	6.5	6.1	6.4	7.7	6.7
Bright'n Early	7.1	5.4	7.4	6.9	6.7
Cascade Spur	5.7	6.3	7.7	8.7	7.1
Classic	7.2	5.1	7.6	5.6	6.4
DixieRed	-	6.2	7.2	6.4	6.6
Hardi-Brite Spur	5.0	4.8	5.8	5.5	5.3
Imperial	5.7	6.8	5.9	6.5	6.2
Mured Royal	6.9	7.7	7.9	7.1	7.4
Oregon Spur	5.2	6.1	6.0	6.6	6.0
Oregon Spur II	5.6	7.1	7.3	9.1	7.3
Real McCoy	-	5.3	5.2	5.2	5.2
Red Prince	5.7	3.3	5.1	5.4	4.9
Redchief(Campbell)	6.6	7.9	8.1	7.5	7.5
Redspur	6.1	5.9	5.8	5.9	5.9
Rose Red	-	5.9	6.7	6.0	6.2
Ruby Red	4.4	5.6	6.7	6.6	5.8
Ruby Stripe	6.5	5.9	7.2	7.3	6.7
Ryanred	5.7	6.7	5.3	5.3	5.7
Ryanred Spur	5.5	5.5	5.8	6.3	5.8
Scarlett Spur	8.9	7.5	7.9	8.8	8.3
Sharp Red	-	6.9	6.8	5.6	6.4
Silver Spur	6.1	6.9	8.3	6.0	6.8
Spur Red	4.1	NA	6.3	6.1	5.5
Starkrimson	6.7	4.9	6.8	5.6	6.0
Sturdeespur	5.1	6.6	7.2	6.6	6.4
Supreme	7.7	6.9	6.8	4.0	6.3
Topred	6.6	5.7	5.2	5.0	5.6
Topspur	5.3	7.0	5.5	4.6	5.6
Triple Red	-	NA	5.8	5.7	5.8
UltraRed	7.1	8.4	8.2	7.7	7.9
UltraStripe	-	8.8	8.6	8.5	8.6
Wayne Spur	4.5	5.9	5.5	6.2	5.5
Wellspur	5.1	5.9	5.8	5.4	5.6
LSD (p = 0.05)	2.8	2.5	2.2	2.3	1.7

Appendix B-1.

TCSA of 'Delicious' strains.

STRAIN	TCSA (cm ²)						
	1982	1983	1984	1985	1986	1987	1988
Ace	1.3	3.1	5.0	9.0	15.3	20.1	31.7
Alred	0.9	2.5	4.8	11.5	22.8	35.2	58.2
Aomori	1.5	2.4	5.1	12.7	24.7	41.6	68.0
Apex	0.5	2.2	4.4	9.9	17.4	23.1	35.8
Bright'n Early	0.8	2.3	5.1	12.5	22.0	36.5	49.4
Cascade Spur	1.4	2.1	4.5	10.3	15.9	26.9	36.8
Classic	1.3	4.2	7.9	17.4	30.2	43.0	66.4
DixieRed	1.2	1.6	3.4	9.5	18.7	32.5	54.4
Hardi-Brite Spur	1.2	3.6	5.8	13.6	21.3	26.8	42.8
Imperial	1.1	3.8	6.8	15.0	26.3	37.2	54.8
Nured Royal	1.2	3.7	6.6	14.6	26.5	38.0	60.4
Oregon Spur	1.6	3.9	6.6	15.0	26.0	37.5	55.9
Oregon Spur II	1.4	3.8	7.6	18.8	32.3	52.2	72.7
Real McCoy	1.5	2.2	4.9	12.7	21.9	37.0	60.1
Red Prince	1.3	3.8	7.6	16.1	31.7	42.9	60.2
Redspur	1.3	3.1	5.5	12.2	21.1	27.6	42.7
Rose Red	1.4	3.0	5.4	12.2	22.2	35.6	57.7
Ruby Red	1.0	2.4	4.2	11.2	20.0	30.8	45.5
Ruby Stripe	1.4	2.8	5.4	13.4	24.0	35.8	56.9
Ryanred	1.1	3.3	5.9	13.0	22.5	36.7	53.3
Ryanred Spur	1.3	2.7	4.2	9.7	17.8	27.1	41.1
Scarlett Spur	2.3	3.9	7.7	16.6	29.7	42.9	59.9
Sharp Red	2.8	4.5	7.8	16.0	29.8	40.0	64.3
Silver Spur	0.6	2.2	4.6	10.1	19.6	28.1	38.4
Spur Red	0.6	2.6	5.0	12.1	18.8	27.3	39.2
Starkrimson	1.5	2.4	5.2	12.4	22.5	36.0	51.7
Sturdeespur	1.0	2.8	4.8	9.4	18.3	23.2	34.3
Supreme	1.4	2.2	4.5	10.4	20.5	30.6	48.7
Topred	1.5	3.6	7.1	16.6	30.5	43.2	68.5
Topspur	1.1	3.0	4.7	9.3	15.1	19.1	28.2
Triple Red	0.8	2.9	6.2	13.6	25.1	35.7	61.6
UltraRed	1.2	1.6	3.5	8.9	16.9	29.0	39.4
Wayne Spur	0.6	2.7	5.8	11.2	20.2	26.5	35.8
Wellspur	2.2	5.3	9.0	15.9	26.8	33.1	55.6
LSD (p = 0.05)	0.3	0.9	2.1	5.2	8.9	12.4	16.1

Appendix B-2.

Yields of 'Delicious' strains.

STRAIN	1985	1986	1987	1988	Total
Ace	3.3	18.1	8.8	13.4	43.6
Alred	0.8	11.0	9.8	17.1	38.7
Aomori	0.0	5.7	5.8	5.5	17.0
Apex	1.9	12.4	9.0	12.6	35.9
Bright'n Early	0.1	4.8	3.0	7.4	15.3
Cascade Spur	3.6	17.7	7.3	22.0	50.6
Classic	0.1	11.4	4.0	8.2	23.7
DixieRed	0.0	4.3	3.7	8.2	16.2
Hardi-Brite Spur	2.9	25.3	8.2	22.2	58.6
Imperial	1.2	22.4	16.9	19.7	60.2
Nured Royal	0.2	11.5	6.8	17.6	36.1
Oregon Spur	1.1	23.0	17.2	26.7	68.0
Oregon Spur II	0.9	10.5	9.2	15.7	36.3
Real McCoy	0.0	5.6	6.2	13.4	25.2
Red Prince	0.4	12.4	14.5	18.0	45.3
Redspur	1.3	19.1	5.7	8.6	34.7
Rose Red	0.0	10.5	3.5	5.1	19.1
Ruby Red	0.6	9.1	7.5	11.4	28.6
Ruby Stripe	0.3	5.7	4.6	10.5	21.1
Ryanred	0.4	15.7	4.4	8.2	28.7
Ryanred Spur	0.7	13.8	4.8	12.6	31.2
Scarlett Spur	0.1	6.7	4.7	5.9	17.4
Sharp Red	0.0	4.8	4.1	8.3	17.2
Silver Spur	0.7	22.3	15.7	23.6	62.3
Spur Red	0.5	11.0	6.4	11.0	28.9
Starkrimson	0.4	4.8	7.7	21.4	34.3
Sturdeespur	1.9	20.2	7.0	11.4	40.5
Supreme	0.3	9.1	9.3	8.6	26.3
Topred	0.2	8.1	6.5	8.1	22.9
Topspur	1.4	11.9	4.1	4.0	21.4
Triple Red	0.0	7.6	2.4	5.4	15.4
UltraRed	0.4	8.1	3.3	8.0	19.8
Wayne Spur	3.4	23.4	16.3	23.7	66.8
Wellspur	0.9	12.4	4.3	10.1	27.7
LSD (p = 0.05)	1.6	8.6	9.0	10.2	25.2

Appendix B-3.

Yield efficiency of 'Delicious' strains.

STRAIN	Yield Efficiency (gm/cm ²)				
	1985	1986	1987	1988	Mean
Ace	393	1208	439	427	617
Alred	56	463	260	270	262
Aomori	0	219	129	80	107
Apex	197	714	401	354	417
Bright'n Early	12	214	75	132	108
Cascade Spur	344	1107	305	596	588
Classic	9	383	91	123	152
DixieRed	0	248	119	157	131
Hardi-Brite Spur	190	1158	308	508	541
Imperial	78	821	432	358	422
Nured Royal	13	439	180	294	232
Oregon Spur	75	896	464	483	479
Oregon Spur II	48	327	177	218	192
Real McCoy	0	257	177	224	165
Red Prince	25	375	322	298	255
Redspur	101	899	201	200	350
Rose Red	0	497	102	92	173
Ruby Red	45	441	228	242	239
Ruby Stripe	20	237	133	187	144
Ryanred	33	705	120	156	254
Ryanred Spur	72	783	180	313	337
Scarlett Spur	6	235	114	97	113
Sharp Red	0	162	104	131	99
Silver Spur	77	1181	565	641	616
Spur Red	44	578	241	273	284
Starkrimson	31	212	214	416	218
Sturdeespur	203	1130	301	338	493
Supreme	24	394	258	152	207
Topred	12	268	154	121	139
Topspur	173	928	229	161	373
Triple Red	0	311	68	88	117
UltraRed	37	476	115	207	209
Wayne Spur	294	1161	630	671	689
Wellspur	58	472	136	191	214
LSD (p = 0.05)	138	336	231	160	160

Appendix C-1.

Length/diameter ratios of 'Delicious' strains.

STRAIN	L/D Ratio				Mean
	1985	1986	1987	1988	
Ace	0.83	0.88	0.87	0.90	0.87
Alred	0.82	0.85	0.84	0.85	0.84
Aomori	-	0.86	0.84	0.86	0.85
Apex	0.84	0.83	0.87	0.88	0.86
Bright'n Early	-	0.86	0.85	0.88	0.86
Cascade Spur	0.82	0.87	0.87	0.89	0.86
Classic	-	0.86	0.84	0.85	0.85
DixieRed	-	0.85	0.85	0.85	0.85
Hardi-Brite Spur	0.80	0.83	0.88	0.85	0.84
Imperial	0.85	0.84	0.85	0.92	0.86
Mured Royal	-	0.88	0.85	0.85	0.86
Oregon Spur	0.78	0.84	0.86	0.89	0.85
Oregon Spur II	0.83	0.87	0.90	0.87	0.87
Real McCoy	-	0.82	0.86	0.83	0.84
Red Prince	0.85	0.85	0.87	0.86	0.86
Redspur	0.83	0.86	0.88	0.88	0.86
Rose Red	-	0.86	0.87	0.88	0.87
Ruby Red	0.82	0.87	0.90	0.88	0.86
Ruby Stripe	0.84	0.87	0.89	0.89	0.88
Ryanred	0.80	0.82	0.83	0.86	0.83
Ryanred Spur	0.80	0.85	0.84	0.88	0.84
Scarlett Spur	-	0.86	0.91	0.84	0.87
Sharp Red	-	0.85	0.84	0.85	0.85
Silver Spur	0.81	0.85	0.88	0.91	0.86
Spur Red	0.85	0.87	0.90	0.90	0.88
Starkrimson	0.86	0.86	0.88	0.86	0.86
Sturdeespur	0.84	0.83	0.90	0.86	0.86
Supreme	0.84	0.88	0.94	0.92	0.90
Topred	-	0.86	0.85	0.87	0.86
Topspur	0.84	0.85	0.86	0.86	0.85
Triple Red	-	0.84	NA	0.86	0.85
UltraRed	0.83	0.84	0.86	0.87	0.85
Wayne Spur	0.81	0.84	0.91	0.89	0.86
Wellspur	0.83	0.85	0.87	0.87	0.86
LSD (p = 0.05)	0.03	0.04	0.04	0.05	0.02

Appendix C-2.

Fruit diameter of 'Delicious' strains.

STRAIN	Fruit Diameter (cm)				Mean
	1985	1986	1987	1988	
Ace	8.7	7.7	8.1	7.5	8.0
Alred	8.4	7.7	8.2	8.0	8.1
Aomori	-	8.2	8.2	7.9	8.1
Apex	8.1	7.8	7.8	7.6	7.8
Bright'n Early	-	7.6	7.9	7.9	7.8
Cascade Spur	8.6	8.0	8.3	7.5	8.1
Classic	-	7.8	7.9	7.5	7.7
DixieRed	-	8.0	7.8	8.0	7.9
Hardi-Brite Spur	8.6	7.8	7.7	7.9	8.0
Imperial	8.4	8.1	8.3	7.9	8.2
Nured Royal	-	8.0	8.1	7.6	7.9
Oregon Spur	8.8	8.3	8.0	7.9	8.3
Oregon Spur II	8.4	7.7	7.8	7.7	7.9
Real McCoy	-	8.2	8.2	8.0	8.1
Red Prince	8.1	8.0	7.8	7.9	7.9
Redspur	8.5	7.8	7.9	7.6	8.0
Rose Red	-	7.9	8.1	7.9	8.0
Ruby Red	7.7	7.3	7.4	7.4	7.5
Ruby Stripe	7.6	7.9	7.8	7.4	7.7
Ryanred	8.4	7.7	8.0	7.7	7.9
Ryanred Spur	8.6	7.9	8.1	7.7	8.1
Scarlett Spur	-	7.8	7.8	7.7	7.8
Sharp Red	-	8.2	8.2	8.0	8.1
Silver Spur	8.9	7.9	8.0	8.0	8.2
Spur Red	8.1	7.4	7.6	7.7	7.7
Starkrimson	8.6	7.6	7.8	7.9	7.9
Sturdeespur	8.3	7.5	7.6	7.9	7.8
Supreme	8.8	7.8	8.1	7.7	8.0
Topred	-	7.8	7.9	7.5	7.7
Topspur	8.2	7.5	7.5	7.4	7.7
Triple Red	-	7.5	NA	7.5	7.5
UltraRed	8.6	8.2	7.8	7.7	8.0
Wayne Spur	8.6	7.8	7.6	7.7	7.9
Wellspur	8.0	7.6	7.5	7.7	7.7
LSD (p = 0.05)	0.4	0.4	0.5	0.5	0.3

Appendix D-1.

Fruit firmness of 'Delicious' strains.

STRAIN	Firmness (lbs)				Mean
	1985	1986	1987	1988	
Ace	13.2	15.8	14.7	13.7	14.4
Alfred	14.6	15.1	15.2	13.6	14.6
Aomori	-	15.9	15.2	14.1	15.1
Apex	14.6	15.6	15.4	14.1	15.0
Bright'n Early	-	15.0	15.3	13.6	14.6
Cascade Spur	13.3	15.0	14.5	13.7	14.1
Classic	-	16.2	15.6	14.4	15.4
DixieRed	-	15.2	14.3	13.0	14.2
Hardi-Brite Spur	13.7	15.6	15.0	14.1	14.6
Imperial	13.3	14.2	15.0	13.2	13.9
Nured Royal	-	15.7	16.0	13.8	15.2
Oregon Spur	14.8	15.2	15.4	13.8	14.8
Oregon Spur II	13.5	14.8	15.2	13.6	14.3
Real McCoy	-	14.6	14.5	13.3	14.1
Red Prince	14.2	14.8	15.8	14.0	14.8
Redspur	12.6	14.6	14.8	13.4	13.8
Rose Red	-	15.4	14.7	13.5	14.5
Ruby Red	13.6	15.8	15.8	14.2	14.9
Ruby Stripe	15.3	14.8	15.2	13.7	14.7
Ryanred	14.0	14.8	15.0	13.2	14.3
Ryanred Spur	13.1	15.6	14.9	13.9	14.4
Scarlett Spur	-	15.5	14.8	13.4	14.6
Sharp Red	-	14.7	14.7	13.9	14.5
Silver Spur	13.4	15.0	14.3	13.7	14.1
Spur Red	14.0	14.7	15.8	13.6	14.5
Starkrimson	12.3	16.0	15.2	13.6	14.6
Sturdeespur	13.5	15.0	15.5	12.7	14.2
Supreme	15.0	16.1	15.8	14.8	15.5
Topred	-	15.5	16.1	14.4	15.4
Topspur	14.2	15.5	16.2	14.7	15.1
Triple Red	-	15.3	NA	14.4	14.9
UltraRed	13.5	14.0	15.5	13.6	14.3
Wayne Spur	13.5	15.4	15.5	14.3	14.7
Wellspur	14.2	15.1	15.7	13.9	14.7
LSD (p = 0.05)	1.8	0.9	1.3	1.1	0.7

Appendix D-2.

Soluble solids of 'Delicious' strains.

STRAIN	Soluble Solids (%)				
	1985	1986	1987	1988	Mean
Ace	14.4	12.0	14.5	13.3	13.5
Alred	15.1	13.8	14.6	13.5	14.3
Aomori	-	14.0	15.5	13.9	14.5
Apex	14.5	12.3	14.0	13.3	13.5
Bright'n Early	-	13.0	14.7	13.5	13.7
Cascade Spur	14.9	12.7	14.5	13.6	13.9
Classic	-	13.6	15.1	13.7	14.1
DixieRed	-	13.1	13.5	13.0	13.2
Hardi-Brite Spur	14.7	12.4	13.5	13.3	13.5
Imperial	15.7	14.3	16.1	14.3	15.1
Nured Royal	-	14.3	15.3	15.2	15.0
Oregon Spur	13.5	12.3	13.3	12.5	12.9
Oregon Spur II	13.1	12.9	13.3	12.9	13.1
Real McCoy	-	15.0	15.1	15.4	15.1
Red Prince	14.8	15.2	15.8	13.9	14.9
Redspur	15.0	11.4	14.4	12.4	13.3
Rose Red	-	13.9	15.5	13.4	14.3
Ruby Red	13.2	12.2	13.5	12.2	12.8
Ruby Stripe	13.5	12.1	13.5	12.1	12.7
Ryanred	15.8	13.9	15.6	14.3	14.9
Ryanred Spur	14.8	13.1	14.7	14.6	14.3
Scarlett Spur	-	11.9	13.5	12.2	12.5
Sharp Red	-	15.0	16.0	15.9	15.7
Silver Spur	13.7	12.9	13.8	12.9	13.3
Spur Red	13.3	12.6	13.5	12.4	13.0
Starkrimson	15.3	13.0	14.4	13.6	13.9
Sturdeespur	14.2	12.6	14.3	13.8	13.7
Supreme	14.0	13.2	14.7	13.2	13.8
Topred	-	14.4	15.8	13.8	14.7
Topspur	15.1	13.0	15.5	13.9	14.4
Triple Red	-	13.9	NA	13.9	13.9
UltraRed	14.6	13.2	13.2	13.7	13.6
Wayne Spur	13.9	12.5	13.8	13.1	13.3
Wellspur	14.6	14.1	14.2	14.0	14.2
LSD (p = 0.05)	1.8	1.4	1.1	1.3	0.8

Appendix D-3.

Starch indexes of 'Delicious' strains.

STRAIN	Starch Index			Mean
	1986	1987	1988	
Ace	4.3	5.4	3.9	4.6
Alred	4.8	5.3	4.3	4.8
Aomori	4.6	5.2	4.3	4.7
Apex	4.2	4.7	5.0	4.6
Bright'n Early	4.6	4.0	4.1	4.2
Cascade Spur	4.8	5.8	4.5	5.0
Classic	4.0	4.7	3.1	4.0
DixieRed	4.5	5.0	4.0	4.5
Hardi-Brite Spur	4.3	5.4	4.6	4.7
Imperial	5.1	5.5	4.4	5.0
Mured Royal	4.4	4.4	4.3	4.4
Oregon Spur	4.0	3.9	3.9	4.0
Oregon Spur II	4.5	4.9	3.9	4.5
Real McCoy	5.4	5.9	5.1	5.5
Red Prince	4.9	4.8	4.3	4.7
Redspur	4.9	6.0	5.1	5.4
Rose Red	4.0	5.3	4.1	4.5
Ruby Red	4.3	4.9	4.1	4.5
Ruby Stripe	4.2	5.2	3.8	4.4
Ryanred	4.8	5.0	4.4	4.8
Ryanred Spur	4.3	5.5	4.6	4.8
Scarlett Spur	4.8	5.3	3.6	4.6
Sharp Red	4.7	5.5	4.0	4.8
Silver Spur	3.4	3.7	4.1	3.7
Spur Red	3.7	5.4	4.4	4.5
Starkrimson	4.4	5.6	4.9	5.0
Sturdeespur	4.5	5.2	5.6	5.1
Supreme	4.3	4.8	3.6	4.2
Topred	4.3	5.0	3.9	4.4
Topspur	4.3	5.0	5.0	4.8
Triple Red	4.4	NA	4.8	4.6
UltraRed	4.3	5.2	5.5	5.0
Wayne Spur	4.1	5.0	4.1	4.4
Wellspur	3.5	4.4	4.8	4.3
LSD (p = 0.05)	0.8	1.0	0.8	0.5

